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Title: **Continuous Method for the Enzymatic Treatment of Vegetable or Animal Tissues**

Continuous Method for the Enzymatic Treatment of Vegetable or Animal Tissues

In the food industry, as well as in technology, enzymatic digestion methods are frequently employed for processing vegetable and animal tissues for obtaining certain components. Previously, these methods were carried out discontinuously. In general, amounts of the order of tons and occasionally of up to 20 tons per batch are employed. For amounts of this magnitude, the surface-to volume ratio usually is small and unfavorable for rapid heating or cooling. As a rule, therefore, the starting up and stopping of the enzymatic treatment proceeds slowly. The further processing on filters or presses is also possible only at a limited rate so that, at the conclusion of the enzymatic steps of the process, much time still elapses before the processing of the treated material is completed. A customary procedure consists therein that the treatment vessel is filled with material, which is to be treated, over a continuously operating mill and at the same time is heated. The enzyme is added simultaneously so that the enzymatic treatment commences already during the filling process. When the filling is completed, the enzyme is allowed to act for the desired amount of time and the contents are subsequently emptied into a continuously operating further step of the process. With this procedure, the advantageous results, which are achieved with laboratory batches of a few liters, cannot be realized on a large, industrial scale.

From a technological point of view, the problem lies in the residence-time distribution during the enzymatic treatment. If the method is set up so that, on the average, the material is treated for the correct residence time under optimum enzymatic treatment conditions, the residence time spectrum is broad and high percentages of treated material are obtained, which have been exposed to the enzymatic action for a period, which is shorter or longer than the correct one. Portions, which have been treated for too short a time, are not digested adequately and, during the recovery of juice, for example, do not give the highest yields possible. Portions, which have been treated

for too long a time enzymatically, can be degraded to such an extent, that the subsequent extraction of juice becomes difficult. Moreover, due to the action of the treatment enzyme or due to the gradual effect of an accompanying enzyme, which is present in a smaller amount and can originate from the enzyme preparation or from the treated material itself, components can be released, which disadvantageously change the taste or the stability or the nature of the end product.

A further disadvantage of the previously customary procedure lies in the unsatisfactory interlinking of the continuous pre-treatment with the discontinuous enzyme treatment and the continuous further treatment steps, which follow thereon. From this point of view, it would be desirable to carry out the enzyme treatment continuously, in that fresh material is filled constantly into the treatment vessel, from which treated material is then removed to the same extent. In so doing, the residence time spectrum would become even wider. By connecting together a series of treatment vessels, through which there is a continuous flow, the equipment cost are increased appreciably; however, the residence time spectrum would not be significantly more advantageous. A narrow residence-time spectrum can be achieved theoretically by a long, thin, treatment pipe, in which there is no back-mixing. Technically, however, it is not possible to convey the pasty or particulate treatment material through such a pipe.

A continuous method has now been discovered for the enzymatic treatment of vegetable or animal tissues, for which the material treated is moved with a narrow residence time spectrum by means of a forced-conveying device through the reaction vessel. The forced-conveying device divides the material treated into narrow segments, which practically do not mixed with adjacent segments. Each segment is moved forward at a defined rate and therefore necessarily passes through the reaction vessel with a precisely defined residence time.

The reaction vessel, may, for example, be a longitudinally extended trough, though which a chain with transporting blades, which largely fill the cross

section of the trough, is moved uniformly. The chain advantageously is endless, is lifted out of the trough at the end of the latter at a guide wheel, runs back over the trough counter to the conveying direction of the treated material and enters the trough once more at the start of the latter by mans of a second guide wheel. It is also possible to use an annular trough with a blade ring, the blades of which start out radially from the center of the ring. The annular ring contains a perforated zone, in which the treated material is emptied. In the subsequent section, the empty segments are filled with fresh material, which is to be treated.

For a preferred embodiment of the invention, a cylindrical reaction vessel is used with a conveying screw, which rotates about the axis of the cylinder. The screw should largely fill up the cross section of the reaction vessel. The ratio of the diameter to the length of the cylindrical vessel may, for example, be between 1 : 1.5 and 1 : 10. Ratios between 1 : 3 and 1 : 5 are most advantageous. In order to achieve good transverse mixing without longitudinal mixing, which would broaden the residence time spectrum, the conveying screw can be interrupted at one or more places, at which a mixer is inserted. For this purpose, externally driven propellers stirrers can be used. However, static mixers are generally preferred, since they do not comminute the treated material additionally. In the end zone of the reaction vessel, the wall may be perforated in screen fashion, in order to withdraw liquid already there. This process can be accelerated owing to the fact that the screw flights become narrower in this region and exert pressure on the treated material. The tissue portion is ejected at the end of the reaction vessel and supplied to the further processing steps.

The inventive method permits one or more enzymes to be introduced into the material to be treated at convenient places, so that different treatment times can be employed for different enzymes. The treatment conditions, such as the temperature or the pH, can also be changed along the flow path. As a result, complicated process sequences under changing conditions, which otherwise could be realized only on an experimental scale, can be carried out continuously on a large industrial scale.

The enzymatic reaction in the discharging, treated material can be terminated quickly. For example, the material can be passed though a heat exchanger, where it is cooled or heated to the inactivation temperature of the enzyme. The enzymatic action can also be terminated in many cases by changing the pH. In other cases, it is sufficient to separate the liquid portion of the emerging treated material on a continuous filter or in a continuous press or centrifuge from the tissue portion, without inactivating the enzyme.

The inventive method is suitable for a plurality of industrial, enzymatic processes. For example, fruit, vegetables, crops, leaves, roots or other vegetable tissue can be processed. Animal tissue, such as meat, offal, bones, animal skins, fish or waste fish can also be processed. Pursuant to the invention, the material to be treated usually is comminuted first so that it assumes a pasty nature. Some crops, such as carrots or apples, can be processed whole or cut into coarse pieces without the addition of liquid. The enzyme is selected depending on the aimed-for process objective. As a rule, hydrolytic enzyme such as pectinases, cellulases, proteinases, amylases or lipases are used. The required process conditions and the optimum duration of the process can be adjusted in the desired manner according to laboratory results. Residence times of 20 minutes up to several hours can be set without technical changes merely by the operating speed of the forced-conveying device in one and the same plant. The rate of advance or rotational speed of the conveying screw is correspondingly low.

The inventive method is suitable for producing fruit and vegetable juices, fruit and vegetable pulp, for digesting vegetable or animal tissue for subsequent extraction processes, for producing protein hydrolysates, for human consumption or as animal feed, for producing organic fertilizers from animal and vegetable waste of different kinds, for recovering collagen from skin waste and for further industrial enzymatic processes. In all cases, the process is conducted continuously, in an optimum manner, from the comminuting machine up to the final stage. Instead of several, batch-

operated, discontinuous, enzymatic treatment reactors, connected between continuous pre-treatment steps and post-treatment steps, the inventive method employs a single, continuous, enzyme-treatment apparatus. The increased equipment costs, which are driven by the installation of the forced-conveying equipment, are compensated for by the limitation to a single such installation instead of several devices, which are connected in parallel.

Claims

1. Continuous method for the enzymatic treatment of vegetable or animal tissues, characterized in that the material treated is moved with a narrow residence-time spectrum by means of a forced conveying device through the reaction vessel.

2. The method of claim 1, characterized in that a cylindrical reaction vessel with a slowly rotating conveying screw is used.